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Life cycle assessment of stormwater management systems for Nørrebro, Copenhagen

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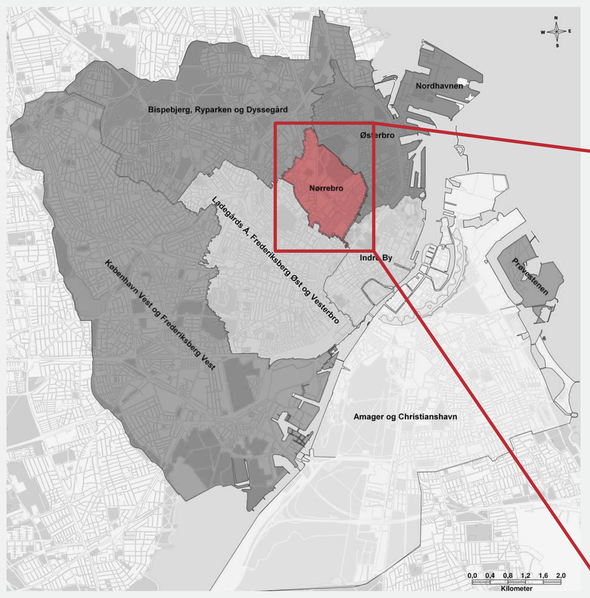
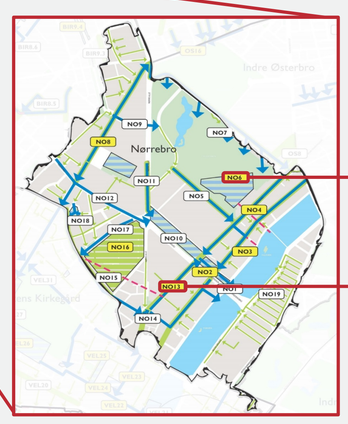
Introduction

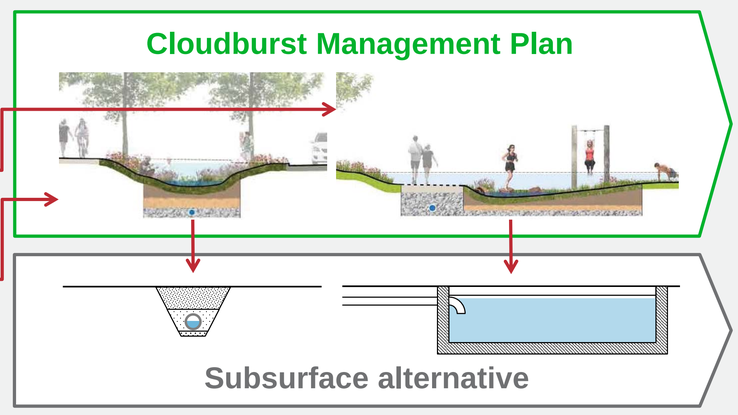
Climate change will lead to more and heavier rain events in Denmark. The existing sewer systems won't be able to cope with the additional runoff and adaptation is necessary, if current flood safety levels are to be met in the future. Numerous elements have to be combined to retain, discharge and purify water. Different approaches to managing stormwater exist, and we are comparing two possible solutions in order to identify the environmentally beneficial alternative.

Stormwater management in Nørrebro, Copenhagen



Nørrebro is a 2.6km^2 large catchment in inner Copenhagen. A Cloudburst Management Plan has been designed by the City of Copenhagen [1] to handle all additional rain expected due to climate change. Local retention and discharge above the surface are key elements. This solution is compared to a more traditional, subsurface alternative, only utilizing pipes and retention basins to handle runoff. The primary functions of both systems are the flood safety targets for different rain intensities.





Primary functions

Rain intensity	Flood safety target
Everyday event	Manage all runoff separately from wastewater
Heavy event	Ensure no water on the surface
Extreme event	Ensure max. of 10cm of water on the surface

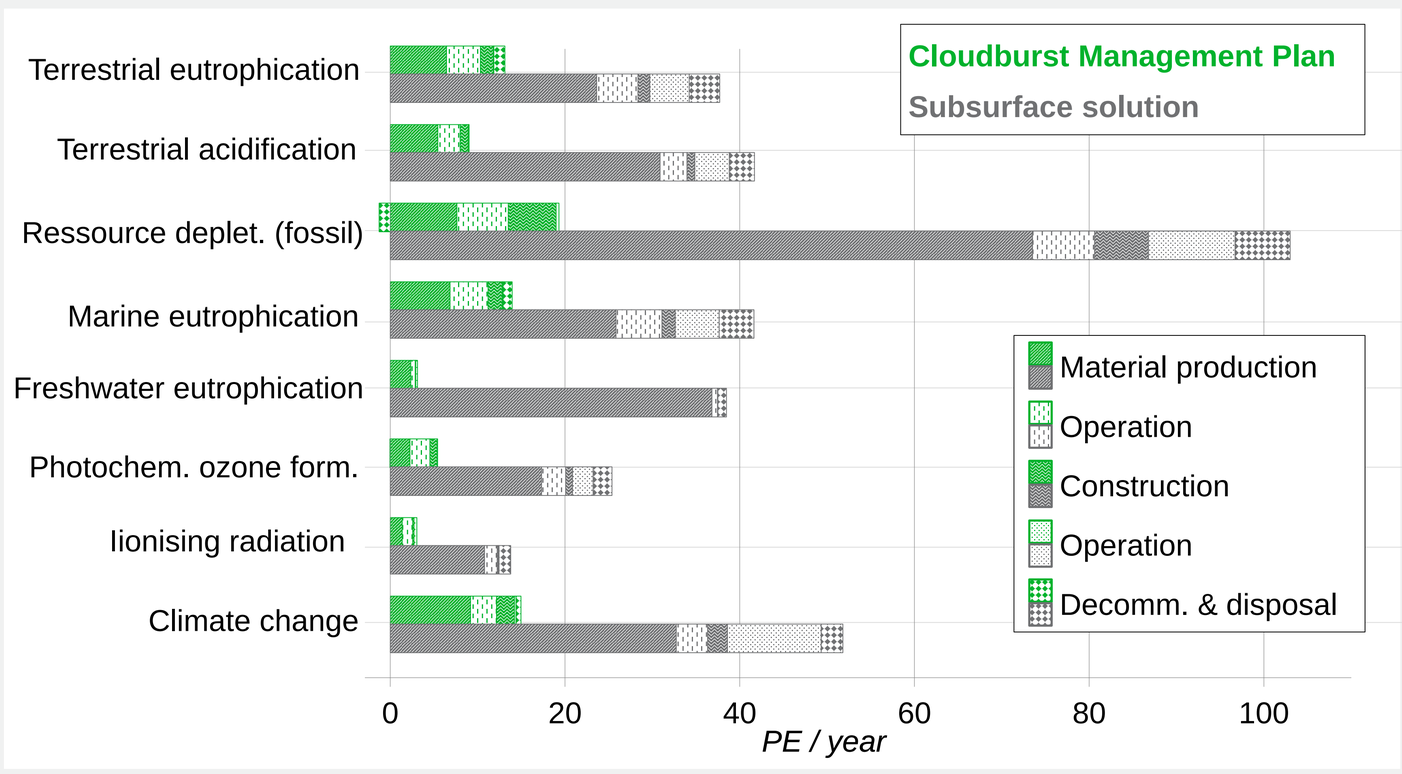
Methods

The life cycle inventory is based on plans, expert interviews and databases. The processes are modelled in EASETECH [2] using the ecoinvent database [3]. The ILCD recommended method was chosen for the impact assessment [4]. The impacts were normalized with reference to the impact of an average person in Europe per year, using the factors developed in the PROSUITE project [5].

Results

Environmental impacts and life cycle stages

The environmental impacts of the Cloudburst Management Plan (3 – 18 PE/year) are significanty lower than the impacts of the subsurface alternative (14 – 103 PE/year). This is mainly due to the high material demands, which cause 63 – 96% of the total impacts of the subsurface alternative, and 42 – 75% of the Cloudburst Management Plan.



Uncertainty

Cloudburst Management Plan

I.		II.
Pipe constr.	Reuse of stones	Channel design
+27%	+13%	-51%
0%	+26%	-51%
+68%	+21%	-52%
0%	+30%	-37%
+72%	+19%	-43%
+39%	+22%	-45%
+45%	+28%	-34%
+68%	+18%	-21%

Subsurface alternative

I.		II.
Pipe constr.	Road materials	Number of basins
+6%	-5%	-13%
0%	-13%	-9%
+13%	-7%	-15%
0%	-3%	-27%
+18%	-6%	-15%
+5%	-11%	-9%
+7%	-8%	-14%
+18%	-6%	-15%

Two different types of uncertainty were tested:

I. Parameter uncertainty: Different input parameters were varied, i.e. construction processes, reuse rates and material demands.

II. Structural uncertainty: Possible changes in the system design were tested, i.e. a "green" channel design for the Cloudburst Management Plan, and a reduction of the number of retention basins for the subsurface alternative.

Conclusion

- The Cloudburst Management Plan has lower environmental impacts in all categories.
- Material production is the life cycle stage contributing most to the total impacts.
- Parameter and structural uncertainty influence the results significantly.
- When taking uncertainty into account, the Cloudbust Managament Plan remains the environmentally preferable solution.

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